Assignment 10

1. H&F Question 3, page 290
2. H&F Question 8, page 299
3. H&F 8.15

4. Consider the following design for a space station called “Tubeworld”: a rigid and thin cylindrical shell of length $L$ and radius $R$ (no ends) with mass $M$ uniformly distributed over the shell.

(a) Calculate Tubeworld’s principal moments of inertia $I = I_1 = I_2$ and $I_3$.

(b) The chosen tipping angle $\theta$ of the symmetry axis relative to the axis about which Tubeworld precesses, and the desired ratio $\omega_p/\omega_3$ of rotation rates, put a constraint on the ratio of the two principal moments of inertia and hence the ratio $L/R$. Express this constraint as a single equation involving these quantities.

(c) Astronomers on Tubeworld will see the heavens rotate about a particular point in the sky, and this point will circle, with angular frequency $\Omega$, the axis of Tubeworld while keeping a fixed angle $\Psi$ with respect to the axis. Determine $\Omega$ and $\Psi$ in terms of the Tubeworld parameters.

(d) In the isolation of empty space the validity of angular momentum conservation is much better than rotational kinetic energy conservation. That’s because mechanical energy (of rotation, etc.) can be taken up by internal motions within Tubeworld (there is indoor plumbing!) and converted into heat, while there is no analogous mechanism for angular momentum. Consider therefore a scenario where, over a long period of time, the rotational kinetic energy of Tubeworld is dissipated without loss of angular momentum. What will be the final tipping angle $\theta'$ and rotation rates $\omega'_p$ and $\omega'_3$?